Text table 2-12.
Foreign S&E doctoral recipients who returned home, by place of origin, selected countries and economies

Location of origin	Total recipients	Percentage who returned home
United Kingdom (1998)		
China	208	59
Malaysia	145	99
Germany	146	57
Greece	118	64
Iran	127	89
United States	80	75
Turkey	124	100
Canada	59	71
Taiwan	82	95
Ireland	61	45
United States (1999)		
China	2,187	10
India	888	10
South Korea	738	37
Taiwan	732	38
Canada	283	28
Turkey	186	41
Germany	179	35
Mexico	158	69
Brazil	156	69
United Kingdom	141	21

NOTES: U.S. data are foreign students with no plans to stay in the United States. Foreign students include those on either permanent or temporary visas.

SOURCES: Higher Education Statistics Agency, First Destination Survey of 1998 Doctoral Recipients, unpublished tabulations, 2001; and appendix table 2-32. *Science & Engineering Indicators – 2002*

graduate study. Economic opportunities, political stability, and institutional conditions for establishing a professional career correlated with high return rates. The fields of agricultural and biological sciences, which receive high funding priorities in some African countries, also correlated with high return rates (Pires, Kassimir, and Brhane 1999).

Foreign doctoral recipients in S&E who remain in the United States represent a potential "brain drain" from their country of origin, but they also have an opportunity for enhanced research experience before returning home. Reverse flow back home is increasing for countries with increasing S&E employment in higher education and research institutes. Little is known of the broader diffusion of S&E knowledge by foreign doctoral recipients who remain in the United States through activities such as cooperative research, short-term visits, and networking with scientists at home and abroad. See sidebar, "Reverse Flow."

Increasing Global Capacity in S&E

This section places data from the United States in an international context, including comparisons of bachelor's (first university) degrees, participation rates in S&E degrees, doctoral degrees, the level of foreign student enrollment, and the percentage of foreign students earning S&E doctoral degrees in major host countries. Information is provided on reforms to improve the quality of expanded doctoral programs in Europe and Asia and the stay rate and return flow of foreign doctoral recipients in a few other major host countries (the United Kingdom and France).

In regard to doctoral degrees, the proportion of S&E degrees earned outside the United States is shifting, which may eventually translate into a corresponding shift in research capacity, scientific output, and innovative capacity. See chapter 4, "U.S. and International Research and Development: Funds and Alliances," and chapter 5, "Academic Research and Development." The United States needs to devise effective forms of collaboration and information exchange to benefit from, and link to, the expanding scientific capabilities of other countries and regions. For example, increased international coauthorship may indicate that the United States is staying in touch with expanded research abroad. See "Scientific Collaboration" in chapter 5.

International Comparison of First University Degrees in S&E Fields

In 1999, more than 2.6 million students worldwide earned a first university degree in science or engineering.[8] (Note that the worldwide total includes only countries for which recent data are available, primarily the Asian, European, and American regions, and is therefore an underestimation.) Approximately 900,000 degrees were earned in fields within each of the broad categories of natural sciences, social and behavioral sciences, and engineering. (See appendix table 2-18.)

From among reporting countries, more than 1.1 million of the 2.6 million S&E degrees were earned by Asian students at Asian universities. Students across Europe (including Eastern Europe and Russia) earned almost 800,000 first university degrees in S&E fields. Students in North America earned more than 600,000 S&E bachelor's degrees. Students in Asia and Europe generally earn more first university degrees in natural science and engineering (NS&E) than in social sciences, whereas the converse is true for students in North America. (See figure 2-25.)

Trend data for bachelor's degrees show that the number earned in the United States remained stable or declined in the 1990s in all fields except psychology and biology. The number of engineering degrees earned in the United States declined from 1986 to 1991, remained nearly stable at the 1991 level for several years, and declined again in 1998. The number of computer science degrees declined from 1986 to 1990, remained essentially flat throughout the 1990s, and increased in 1998. In contrast, trend data available for selected Asian countries show strong growth in degree production in all S&E

[8] A first university degree refers to the completion of a terminal undergraduate degree program. These degrees are classified as level 5A in the International Standard Classification of Education, although individual countries use different names for the first terminal degree (for example, *laureata* in Italy, *diplome* in Germany, *maitrise* in France, and *bachelor's degree* in the United States and in Asian countries).

Reverse Flow

Systematic data are not available on the contributions that returning Ph.D.-holding scientists and engineers make to the science and technology (S&T) infrastructure of their home countries. Evidence suggests that they fill prominent positions in universities and research institutes. For example, college catalogs of universities in developing countries show the location of the doctoral education of science and engineering (S&E) faculty. Senior academic staff and directors of research centers typically receive their doctoral education from research universities in the United States, the United Kingdom, or France.* The following are four broad categories of reverse flow that contribute to the circulation of S&T knowledge. They are distinguished by location and duration. The first two categories relate to actually moving back home for permanent or temporary positions. The last two categories relate to short- and long-term activities conducted with the home country while employed abroad.

Employment Offers to Scientists and Engineers Trained Abroad

Taiwan and South Korea have been the places most able to immediately absorb Ph.D.-holding scientists and engineers trained abroad who contribute through teaching and research in universities and research parks (NSF/SRS 1998). Research and development (R&D) centers of foreign businesses in these countries also employ returning scientists and engineers, e.g., Motorola Korea Software Research Center and the South Korea International Business Machines (IBM) Tivoli Software Development Center (*The Korean-American Science and Technology News* 1998). Multinational R&D centers are also being established in China by Microsoft, Hewlett-Packard, and IBM (*China Daily* 2001a). A relatively small percentage of South Korean and Taiwanese doctoral recipients from universities in the United States plan to stay in the United States. (See appendix table 2-32.) Many of those who remain in the United States to pursue academic or industrial research experience eventually return to their home country.

In contrast, China and India can offer S&T employment to only a small fraction of their students who earn advanced degrees in S&E fields at universities in the United States. Most of these students remain in the United States, initially for postdoctoral research or for research in industry (NSF/SRS 1998). Those who do return later are usually recruited for a national research priority; for example, the recently established Brain Research Center in New Delhi hired top Indian scientists from home and abroad (American Association for the Advancement of Science 1999). The human genome center at the Chinese Academy of Science's Institute of Genetics in China attracted top young Chinese microbiologists and geneticists for 20 research groups formed in Beijing and Shanghai to sequence part of the human genome (Li 2000). More programs are being created in China to attract outstanding scientists and engineers to top faculty positions and to lead research programs in their disciplines (Guo 2001).

Besides immediate or delayed returns, reverse flow to a home country sometimes occurs after a long, distinguished scientific career abroad. Incidents of prominent scientists returning to their countries are noted in science journals. For example, Yuan T. Lee earned a doctorate in chemistry at the University of California–Berkeley, headed a top laboratory, and eventually earned a Nobel Prize for his research. Many years later, he returned home to head Taiwan's Academia Sinica, a collection of 21 research institutes (Nash 1994).

Temporary Positions for Scientists and Engineers Trained or Working Abroad

Besides various permanent positions, reverse flow can be the result of an offer for an attractive temporary S&E position or for access to high-technology parks with desirable conditions. For example, the government of Ireland's Science and Technology Agency (FORFAS) is funding basic science with five-year grants that are attempting to draw Irish scientists and engineers back to establish laboratories in Irish universities. (Previously educated in Ireland, the graduates left for employment in the United Kingdom or the United States.) Although not offered permanent positions, they would have funding to lead a research area for five years.† A different type of temporary arrangement is China and Taiwan's use of preferential status (no taxes for two to three years) for those who will try to start up a company within an industrial park (*China Daily* 2001b). Another example of a temporary position is transferring to an R&D position within a multinational firm operating in the home country or accepting a two- to three-year appointment in the home country while maintaining ties in the United States. For example, in 2001, Hong Kong University of Science and Technology hired Dr. Paul Chu of the University of

*See, for example, the international academic credentials of the S&E faculty in recent college catalog of Bilkent University, Ankara, Turkey, and Hong Kong University of Science and Technology.

†Personal communication with Rhona Dempsey, Manager, S&E Indicators, Science & Technology Division, The National Policy and Advisory Board for Enterprise, Trade, Science, Technology and Innovation (FORFAS), NSF, Arlington, VA, March 2001.

Houston as its new president for a three-year appointment, but he maintains his laboratory on High Temperature Superconductivity in Houston (Cinelli 2000).

Long-Term Collaborative Research Arrangements

Some scientists remain abroad but establish and maintain a long-term relationship with researchers in their home country through periodic visits, international conferences and workshops, short courses and workshops at their home institutions, and collaborative research. For example, Samuel Ting, Nobel laureate in physics, Professor at the Massachusetts Institute of Technology (MIT), and member of Taiwan's Academia Sinica, encourages collaboration of teams of scientists in 16 countries and Taiwan. As chairman of the Alpha Magnetic Spectrometer (AMS) research program under the Department of Energy and National Aeronautics and Space Administration, Ting established international collaboration with Taiwanese researchers to manufacture all AMS electronics (*Taipei Update* 2001). In addition, U.S. cooperative science programs with China and India funded by the National Science Foundation often provide grants to Chinese and Indian scientists in the United States collaborating with a home-country scientist.[†]

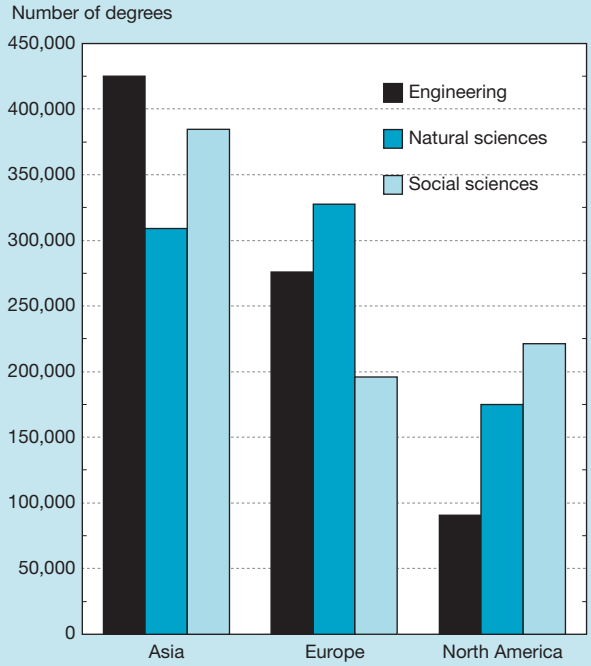
Intermittent Networking

Another mechanism for scientific information flow is networking of scientists abroad with scientists in their home country. Because of economic and political crises, several Latin American countries have lost scientists and engineers to other countries in the region or outside Latin America. Colombia was the first to attempt to link to these "lost" scientists and engineers working abroad and to reframe the concept from "brain drain" to "brain gain." In the early 1990s, the Caldas program in Colombia linked all expatriate Colombian scientists to advise on scientific and economic development schemes (Charum and Meyer 1998). Approximately 40 countries have since devised such networking schemes, and others are working to implement programs (Meyer 2001).

Some countries are able to use all types of reverse flow, absorbing their scientists and engineers in temporary or permanent positions and promoting links through international collaboration or visits.

[†]See abstracts of awards for grants and workshops with China and India at the NSF website: <http://www.nsf.gov>.

Figure 2-25.
First university degrees in S&E fields in selected countries, by region: 1999 or most recent year



NOTES: Natural sciences include physics, chemistry, astronomy, and earth, atmospheric, ocean, biological, and agricultural sciences, as well as mathematics and computer sciences. Social sciences include sociology, psychology, and other social sciences.

See appendix table 2-18 for countries and economies included within each region.

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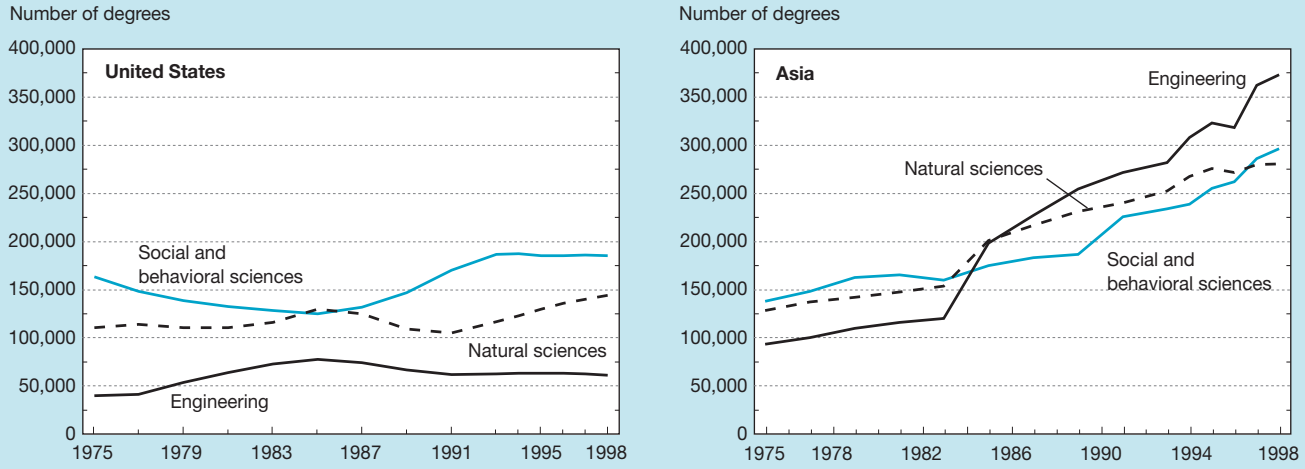
fields. At the bachelor's level, institutions of higher education in Asian countries produce approximately six times as many engineering degrees as do institutions in the United States. (See figure 2-26.) The number of degrees earned in NS&E fields in a country is reflected in the skill level of the labor force and may explain some of Asia's increased capacity in high-technology manufactures and exports. See chapter 6, "Industry, Technology, and the Global Marketplace."

For the past three decades in the United States, overall S&E degrees awarded represented about one-third of the total number of bachelor's degrees. Among some Asian countries and economies, S&E degrees represent a considerably higher proportion of total degrees. In 1999, S&E degrees represented 73 percent of total bachelor's degrees earned in China, 45 percent of total bachelor's degrees earned in South Korea, and 40 percent of total bachelor's degrees earned in Taiwan.

International Comparison of Participation Rates in University Degrees and S&E Degrees

Most countries agree with the notion that a shift to a technology-based economy brings national advantage and that the ability to do so depends on highly educated citizens. Especially important are people educated in science, mathematics, and engineering (Greenspan 2000). A high ratio of the college-age population earning university degrees correlates with better public understanding of science, and a high proportion of the college-age population earning NS&E degrees correlates with the technical skill level of those entering the workforce.

Figure 2-26.
Bachelor's S&E degrees in the United States and selected Asian countries and economies, by field: 1975–98



NOTES: Asian countries and economies include China, India, Japan, South Korea, and Taiwan. Natural sciences include physics, chemistry, astronomy, biological, and earth, atmospheric, ocean, agricultural sciences, as well as mathematics and computer sciences. Data for China are included after 1983.

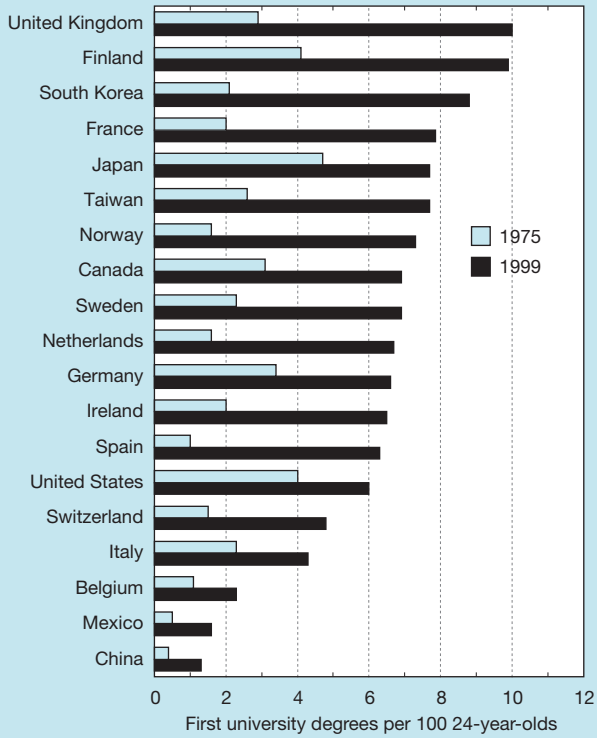
See appendix table 2-33. *Science & Engineering Indicators – 2002*

Traditionally, the United States has been a world leader in providing broad access to higher education. The ratio of bachelor's degrees earned in the United States to the college-age cohort is relatively high—35 per 100 in 1998. However, other countries have expanded their higher education systems, and the United States is now 1 of 10 countries providing a college education to approximately one-third or more of their college-age population. In more than 16 countries, the ratio of natural science and engineering (NS&E) first university degrees to the college-age population is higher than that in the United States. The ratio of these degrees to the population of 24-year-olds in the United States has been between 4 and 5 per 100 for two decades and reached 6 per 100 in 1998. South Korea and Taiwan dramatically increased ratios of NS&E first university degrees earned by 24-year-olds, from 2 per 100 in 1975 to 9 per 100 in South Korea and almost 8 per 100 in Taiwan in 1999. At the same time, several European countries have doubled and tripled the ratio of young people earning NS&E first university degrees to between 8 and 10 per 100. (See figure 2-27.)

International Comparison of Participation Rates by Sex

Among Western countries for which degree data are available by sex, the United Kingdom, Canada, and the United States show relatively high participation rates for both men and women in first university degrees. Among these countries, women in the United Kingdom have the highest participation rate in first university degrees. In 1999, the ratio of women-earned first university degrees to the female 24-year-old population was 41 per 100, slightly higher than the ratio in the United States and Canada (38–40 per 100). Women in the United Kingdom and Canada also show high participa-

Figure 2-27.
Ratio of natural science or engineering first university degrees to 24-year-old population, by country or economy



NOTES: Natural sciences include physics, chemistry, astronomy, and earth, atmospheric, ocean, biological, agricultural, as well as mathematics and computer sciences. The ratio is the number of natural science and engineering degrees to the 24-year-old population. China's data are for 1985 and 1999. Other countries' data are for 1975 and 1998 or 1999.

See appendix table 2-18. *Science & Engineering Indicators – 2002*

tion rates of NS&E bachelor's degrees earned. In 1999, the ratio of NS&E first university degrees earned by women in the United Kingdom to the female 24-year-old population was 7.5 per 100, still far less than the rate for U.K. men. Participation rates for men and women in Canada are more similar. (See text table 2-13 and appendix table 2-34.)

In Asian countries, women earn first university degrees at a rate similar to or higher than those in many European countries. However, only in South Korea do women have high participation rates in first university NS&E degrees. In 1998, the ratio of women-earned degrees in these fields to the female 24-year-old population was 4.9 per 100, higher than the participation rate of women in other Asian countries, Germany, or the United States. (See text table 2-13.) Among all reporting countries, women earned the highest proportion of their S&E degrees in natural and social sciences. (See appendix table 2-34.)

International Comparison of Foreign Student Enrollment in S&E Programs

Despite a decline in foreign graduate student enrollment in the United States from 1994 through 1996, the current flow of foreign S&E students to the United States and other industrialized countries is increasing. Some of the factors that have fostered this flow to advanced countries are an increasing focus on academic research and declining college-age populations. See "Demographics and Higher Education." The policies of the European Union (EU) to foster comparable degrees and transferable credits augment the inter-European mobility of students and faculty (Koenig 2001b). The group of traditional host countries for many foreign students (United States, France, and United Kingdom) is expanding to include Japan, Germany, Canada, and Australia. This section compares foreign student enrollment in S&E programs in some of these countries.

The United Kingdom has traditionally educated numerous foreign students, many of whom have come from Britain's former colonies in Asia and North America (particularly India, Malaysia, and Canada). In the 1990s, the proportion of foreign students studying S&E fields in the United Kingdom increased at both the graduate and undergraduate levels. From 1995 to 1999, foreign undergraduate students in S&E increased from 8.8 to 11.6 percent. Engineering received a higher concentration of foreign students as undergraduate enrollment in engineering in U.K. universities declined from 113,000 in 1995 to 100,000 in 1999. At the same time, the enrollment of foreign students in engineering rose from 16,000 in 1995 to 21,000 in 1999, representing 21 percent of all undergraduate engineering students in U.K. universities in 1999, up from 14 percent in 1995. (See text table 2-14 and appendix table 2-35.)

During the same period, U.K. universities also increased enrollment of foreign students within their graduate S&E departments. Foreign S&E graduate student enrollment rose from 28,848 in 1995 to 36,631 in 1999, an increase of 27 percent. Concurrently, U.K. universities increased the percentage of foreign S&E students at the graduate level from 28.9 to 31.5 percent. Percentages of foreign students differ by field. In 1999, foreign student graduate enrollment reached 37.6 percent in engineering and 40 percent in social and behavioral sciences. (See figure 2-28 and appendix table 2-35.)

European countries are receiving more students from within EU countries. By 1999, at U.K. universities, the number of foreign graduate students from other EU countries was three times higher than the number of foreign students from Britain's former colonies (Malaysia, Hong Kong, and India). (See text table 2-15 and appendix table 2-35.) Graduate students from EU countries represent approximately 7 percent of the graduate students in sciences in U.K. universities and approximately 11 percent of the graduate engineering students. Chinese students, who represent about one-third of foreign S&E graduate students at universities in the United States, make up only 4 percent of S&E graduate students at U.K. universities. (See appendix tables 2-21 and 2-35.) Students from Greece have traditionally attended other European universities and universities in the United States for graduate education. After Greece, however, German students account for the second highest number of foreign graduate students at U.K. universities.

Text table 2-13.
Ratio of NS&E degrees to 24-year-old population, by country and sex: 1998–99

Country	Female	Male
Japan	2.3	12.8
United Kingdom	7.5	12.5
South Korea	4.9	12.4
Canada	5.7	7.9
Germany	4.3	7.7
United States	4.6	7.5
Mexico	0.9	2.4

NS&E = natural science and engineering

NOTES: Natural sciences include physics, chemistry, astronomy, and earth, atmospheric, ocean, biological, agricultural, as well as mathematics and computer sciences. The ratio is the number of NS&E degrees to the 24-year-old population.

See appendix table 2-34.

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Text table 2-14.
Enrollment of foreign students in undergraduate engineering, selected countries: 1998–99

Country	Total engineering enrollment	Foreign enrollment	Percent foreign
United Kingdom	99,900	20,811	20.8
United States	366,991	21,110	5.8
Japan	471,310	3,322	0.7

NOTE: U.S. data are 1998; U.K. and Japan data are 1999.

SOURCES: American Association of Engineering Societies, Engineering Workforce Commission, *Engineering and Technology Enrollment, Fall 1999* (Washington DC, 2000) and appendix tables 2–35 and 2–37.

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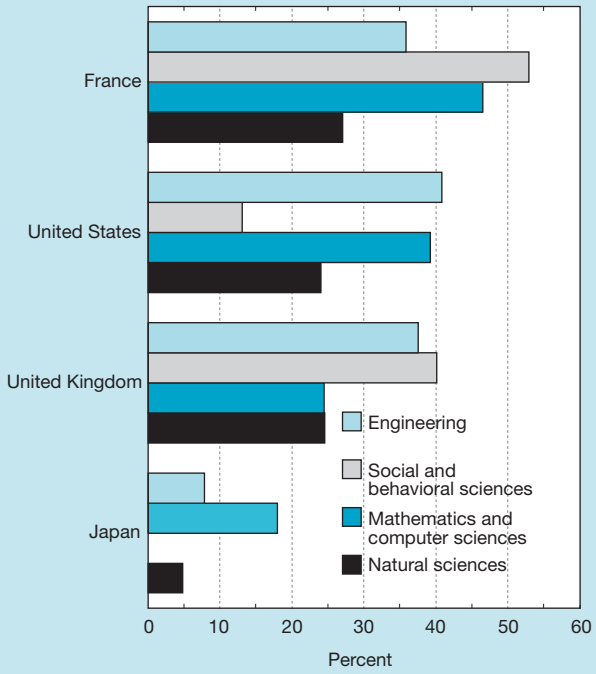
Figure 2-28.
Foreign graduate student enrollment in selected countries, by field: 1999



NOTES: French data include foreign doctoral students only; Japanese data include mathematics in natural sciences and computer sciences in engineering. Natural sciences include physics, chemistry, astronomy, and earth, atmospheric, ocean, biological, and agricultural sciences.

See appendix tables 2-20, 2-35, 2-36, 2-37, and 2-38.

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Text table 2-15.
Foreign graduate students in S&E fields in U.K. universities, by region of origin: 1999

Region	Number
Total	36,000
Europe	15,000
Asia	10,000
Africa	3,000
Middle East	3,000
North America	3,000
South America	1,000
Central America	600

SOURCE: Higher Education Statistics Agency, unpublished tabulations (2001).

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Foreign students also are attracted to France for graduate programs in S&E. French universities have a long tradition of educating foreign students and have a broad base of countries of origin of foreign doctoral students (more than 150), primarily developing countries in Africa, Latin America, and Asia. Approximately 15 percent of the foreign students in French doctoral programs come from neighboring European countries. In 1998, most of the 17,000 foreign doctoral students who entered French universities enrolled in S&E fields. (See appendix table 2-36.) Foreign students enrolled in S&E doctoral programs represent about 26 percent of S&E doctoral enrollment, somewhat smaller than the proportion of foreign students in U.S. graduate enrollment. (See figure 2-28.)

Japan and Germany also are attempting to bolster their enrollment of foreign students in S&E. Japan's goal of 100,000 foreign students, promulgated in the 1980s, has never been met but is once again being discussed as a serious target. In 1999, 55,000 foreign students enrolled in Japanese universities, mainly at the undergraduate level (34,000) and concentrated in social sciences (13,000) and engineering (3,000). In that year, about 22,000 foreign students enrolled in graduate programs in Japan, mainly from China and South Korea, representing 10 percent of the graduate students in S&E fields. (See appendix table 2-37.) Germany is also recruiting foreign students from India and China to fill its research universities, particularly in engineering and computer sciences (Grote 2000; Koenig 2001a).

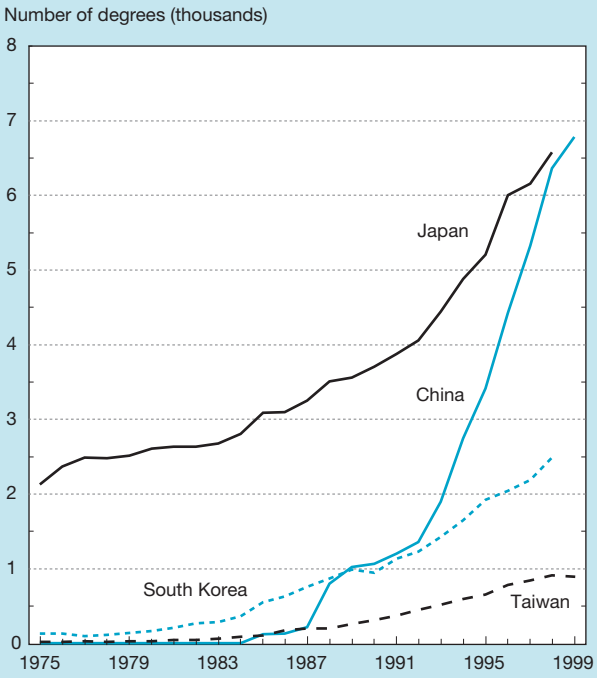
International Comparison of Doctoral Degrees in S&E Fields

The development of increasing institutional capacity to provide advanced S&E education through the highest levels is indicated in trend data for earned doctorates in selected countries of Europe and Asia. Japan has doubled its S&E doctoral degree production within the past decade. Developing Asian countries, starting from a very low base in the 1970s and 1980s, have increased their S&E doctoral education by several orders of magnitude. China, Japan, South Korea, and Taiwan have established new institutions for graduate education in S&E and expanded their S&E graduate programs in existing national universities. China now has the largest capacity for S&E doctoral degree production in the Asian region (see figure 2-29) and ranks fifth in the world. In Europe, France, Germany, and the United Kingdom have almost doubled their S&E doctoral degree production in the past two decades, with slight declines in 1998. (See figure 2-30.) All of these countries are engaged in reforms to improve the quality of doctoral research programs. See sidebar, "International Efforts in Doctoral Reform."

The growing capacity of some developing Asian countries and economies (China, South Korea, and Taiwan) for advanced S&E education decreases the proportion of doctoral degrees earned by their citizens in the United States. (See figure 2-31.) For example, in the past five years, Chinese and South Korean students earned more S&E doctoral degrees in their respective countries than in the United States. Taiwanese students have also become less dependent on the United States for advanced training; in 1999, for the first time, they earned more S&E doctoral degrees at Taiwanese universities than at universities in the United States.

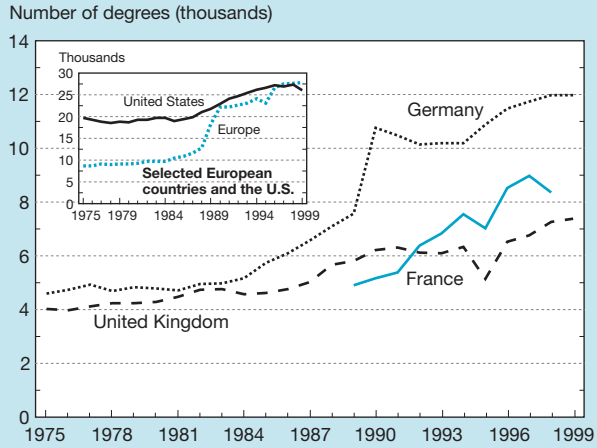
In 1999, Europe produced far more S&E doctoral degrees (54,000) than the United States (26,000) or Asia (21,000). Considering broad fields of science, most of the doctorates earned in natural sciences, social sciences, and engineering are earned at European universities. The United States awards

Figure 2-29.
Doctoral S&E degrees earned in selected Asian countries and economies: 1975–99



See appendix table 2-39. *Science & Engineering Indicators – 2002*

Figure 2-30.
Doctoral S&E degrees in selected industrialized countries: 1975–99



NOTES: The peak in the data from Germany in 1990 reflects the inclusion of degrees from former East Germany. The inset combines the three European countries.

See appendix table 2-40. *Science & Engineering Indicators – 2002*

more doctoral degrees in natural and social sciences than Asian countries. (See figure 2-32.)

Trend data for NS&E doctoral degrees (excluding social sciences) show that Asian universities educated more students at the doctoral level in these fields than universities in the United States in the late 1990s. (See figure 2-33.) In 1999, Asian universities awarded more engineering doctoral degrees but fewer natural science degrees than universities in the United States. (See appendix tables 2-39 and 2-40.)

Considering the proportion of S&E doctoral degrees by sex, women in Europe and the United States earn a higher proportion of such degrees than women in Asia. Women in France and the United States earned more than a third of S&E doctoral degrees in their respective countries in 1999. Women in Japan, Taiwan, and South Korea earned about 10 percent of such degrees. (See appendix table 2-43.)

International Comparison of Foreign Doctoral Recipients

Like the United States, the United Kingdom and France have a large percentage of foreign students in their S&E doctoral programs. In 1999, Germany was the top country of origin of foreign S&E doctoral degree recipients in the United Kingdom, China was the top country earning S&E doctoral degrees in the United States, and Algeria was the top country of origin of foreign students studying for S&E doctoral degrees in France. (See appendix tables 2-32, 2-36, and 2-44.) In 1999, foreign students earned 44 percent of the doctoral engineering degrees awarded by U.K. universities, 30 percent of those awarded by French universities, and 49 percent of those awarded by universities in the United States. In that same year, foreign students earned more than 31 percent of the doctoral degrees awarded in mathematics/computer sciences in France, 38 percent of those awarded in the United Kingdom, and 47 percent of those awarded in the United States. (See figure 2-34.) In addition, Japan and Germany have a modest but growing percentage of foreign students among their S&E doctoral degree recipients. (See appendix table 2-45.)

International Comparison of Stay Rates

Data similar to the data on "plans to stay" in the annual SED are available on the first destination of foreign doctoral students in the United Kingdom and France after earning their degree. Data from the U.K. Higher Education Statistics Agency show that, in 1998, most foreign S&E doctoral degree recipients at U.K. universities returned home after earning their degree. In fact, among the 10 top countries of origin, all doctoral recipients from Malaysia and Turkey returned to their home country. Ireland is the only exception, with 45 percent of doctoral recipients returning to Ireland as their first destination after receiving their degree. (See text table 2-12.)

Doctoral survey data from the French Ministry of Education, Research, and Technology show that the return rate for foreign S&E doctoral recipients is lower in France than in the United Kingdom. Data are not available on the return rates of French foreign doctoral recipients by countries of origin, but return rates are available by S&E field of study. In 1998, the overall return rate of foreign doctoral recipients from France to their countries of origin was 28 percent in natural sciences and 20 percent in engineering fields. (See text table 2-16.)

International Efforts in Doctoral Reform

Doctoral reforms in European and Asian countries are strengthening the university sector to become an explicit component of national innovation systems. The goals are to develop the capacity for breakthrough research leading to innovative products and successful markets, to stem "brain drain," and to attract top scientists to the country (NSF/INT 2000). Doctoral reforms also include providing national universities with more autonomy in hiring faculty and governance of academic programs and providing additional funds. International networks of universities share curriculum development and distance education.

Asian countries are using various mechanisms to improve the quality of doctoral programs and to upgrade equipment and facilities for academic research. World-class facilities often require international partnerships (Bagla 2000). For example, the Indian Institute of Technology (IIT) in Delhi is partnering with the International Business Machine research center on its campus for graduate research opportunities and exchange of faculty. In China, Shanghai's Fudan University and Bell Labs have a joint laboratory for software development and information technology (IT) (*China Daily* 2001b). In addition, research parks throughout Asia are concentrating high-technology industries next to top universities to attempt to create a "Silicon Valley." For example, Beijing's research park includes Peking University, the Chinese Academy of Sciences, and 4,000 high-technology enterprises (*China Daily* 2001a).

European countries are experimenting with doctoral reforms that prepare students not only to increase the store of basic science but also to apply knowledge to innovative technologies and find solutions to the problems confronted by society (Carlson 2001). Doctoral reform in France brings university research programs closer with the network of national laboratories (CNRS). For example, the CNRS Laboratory of Material Physics and two university labs are forming a Materials Center to be part of a large research complex outside Rouen (Carlson 1999).

Doctoral reforms in Europe also include international partnerships to create centers of excellence, some through the EU and some trans-Atlantic centers. The centers of excellence are designed both to improve the quality of research and to stem brain drain to other countries. For example, the University of Cambridge in Cambridge, England, and the Massachusetts Institute of Technology (MIT) in Cambridge, Massachusetts, are collaborating on the Cambridge-MIT Technology Institute. These two leading research universities will develop common courses and exchange faculty and students (Tugend 1999). A second MIT partnership, the MIT MediaLabEurope in Dublin, will build on Ireland's strength in computer sciences to become a center of excellence in IT for Europe (Birchard 2001).

Countries and other places are using various funding sources, either public or private, to upgrade equipment and facilities. For example, Taiwan is publicly funding infrastructure improvements, as are industrialized countries such as Japan and those within the European Union. The U.K. government has recently committed large funds to improve deteriorating facilities and to raise stipends for doctoral students (Stone 2000; Urquhart 2000). China has used international funding sources to improve higher education (Hayhoe 1989) and is assisting the top universities in becoming financially independent through their partnerships with high-technology industries (China Daily 2001b). Hong Kong and South Korea have built science and technology (S&T) universities with business donations. The philanthropy of Indian scientists and engineers in the United States with successful companies is upgrading the IIT's facilities and creating new S&T universities in India (Goel 2000; Bagla 2000).

Conclusion

Students in the United States are as interested in studying some fields of science as they were in the past, but the declining level of interest in engineering and physical sciences still raises national concern. From 1975 to 1998, approximately one-third of all bachelor's degrees were earned in S&E fields. However, the distribution among natural sciences, social sciences, and engineering has changed. The approximately 12 percent of degrees earned in natural sciences are not as evenly distributed across physical and biological sciences as in previous decades. The number of degrees earned in biological sciences continues to increase, whereas the number earned in other natural sciences is dropping off. Engineering degrees, which represented 8 percent of all bachelor's degrees awarded in 1986, slowly dropped to 5 percent of all bachelor's degrees awarded in 1998. In addition, other countries award a higher percentage of bachelor's degrees in S&E fields; among European and Asian countries, the average is about 40 percent and it is considerably higher for some emerging Asian countries.

The United States has programs to increase access to S&E education for groups that were formerly underrepresented in S&E fields. Because these groups represent the growing segment of the population in the United States, an adequate future workforce will require that minorities choose careers in S&E. To date, modest progress has been made toward increasing the proportion of these minority college-age populations earning NS&E degrees. In 1998, among whites, the ratio of